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Science and The New Era

By

ARCHIBALD HENDERSON

To-day we live in the midst of a Great Awakening—that "awakening from dogmatic slumber" of which Immanuel Kant so pungently spoke. Under the magic touch of wizard hands—of Einstein, Planck, and Bohr, of Michelson, Millikan and Hopkins,—the leaden lids of a slumbering civilization are lifted, for eyes to view anew the cosmos with sharpened vision and startled interest. The miracles of contemporary science herald and summon a "renascence of wonder" of which Watts-Dunton little dreamed. The miracles of Scripture were miracles of sense—of sight and sound and touch. The miracles of modern science are miracles of the invisible, the intangible, I had almost said the occult. No one has ever seen an electron; no Anström unit is large enough for measurement by a scale held in the hand; the enormous gravitational force of the companion of Sirius is fortunately beyond our ken. In this era when Science writes romances beside which Art pales its ineffectual fires, a supreme credulity is the first requirement of its aptest votaries. The science of the past was grounded upon the demonstrable evidence of the senses. The science of the present is realising the fantasies of "Alice in Wonderland" and "Through the Looking Glass." The imaginative scientist of to-day imposes as his first condition the voluntary abdication of "common sense." As my friend, Bernard Shaw, has wittily expressed it in his preface to *Saint Joan*: "The mediaeval doctors of divinity who did not pretend to settle how many angels could dance on the point of a needle cut a very poor figure as far as romantic credulity is concerned beside the modern physicists who have settled to the billionth of a millimetre every movement and position in the dance of the electrons . . . Why the men who believe in electrons should regard themselves as less credulous than the men who believed in angels is not apparent to me . . . In the Middle Ages people believed that the earth was flat, for which they had at least the evidences of their senses; we believe it to be round, not because as many as one per cent of us could give the physical reasons for so quaint a belief, but because modern science has convinced us that nothing that is obvious is true, and that everything that is magical, improbable, extraordinary, gigantic, microscopic, heartless or outrageous is scientific."

Allow me to take illustrations from the subjects in which I work: mathematics, physics and astronomy—to convince you of the extraordinary developments and phenomenal achievements of modern science. Pure mathematics had its birth as late as the nineteenth century, although like most true sciences it was "baptized long before it was born." This modern science, which we owe to the Englishman Boole, the American Peirce, the Italian Peano, "consists entirely of asseverations to the effect that, if such and such a proposition is true of *anything*, then such and such another proposition is true of *that thing*. It is essential not to discuss whether the first proposition is really true, and not to mention what the *anything* is, of which it is supposed to be true." It is from such irreproachable premises of formal logic that my old teacher at Cambridge University, the brilliant Bertrand Russell, disengaged this witty and accurate definition: "Mathematics may be defined as the subject in which we never know what we are talking about, nor whether what we are saying is true." I venture to hope that those of you who find mathematics puzzling and incomprehensible may derive abiding comfort from this paradoxical definition and experience profound faith in its essential accuracy.

Pure mathematics is a subject which is generally regarded as the scientific Mah Jongg of mad mandarins, utterly useless and futile. I invoke for you Simon Newcomb's famous toast: "Here's to Mathematics; may it never be of use to anybody!" And I would remind you that on one occasion, after reading a highly theoretical paper on the theory of numbers to a scientific body, the English mathematician, H. J. S. Smith, blandly remarked: "It is the peculiar beauty of this method, gentlemen, and one which endears it to the really scientific mind, that under no circumstances—thank God!—can it ever be of the smallest possible utility!" Little did Bolyai and Lobatchewsky, I daresay, dream of practical applications when they were developing the highly speculative and weirdly geometrical mental constructs of non-Euclidian geometry. In their analyses of elliptical and spherical space Klein and Newcomb were actuated solely, no doubt, by their interest in the esoterism of pure mathematics. Never was there a more theoretical subject, I daresay, than that of the Absolute Differential Calculus propounded but a few decades ago by the Italian mathematicians, Ricci and Lévi-Civíta. And yet, when Einstein needed the most delicate mathematical instruments and machinery for the construction of his towering structure of Relativity, involving an entirely new mechanics, he found it, miraculously enough, in the purely theoretical and "entirely useless" contributions of Bolyai and Lobatchewsky of Klein and Newcomb, of Ricci and Lévi-Civíta.

The real marvel of contemporary science is not merely that it predicts miracles: it brings them to pass. Three quarters of a century ago, the French astronomer, Leverrier, on the basis of certain observed disturbances in the planet Uranus, and after elaborate calculations in the domain of the problem of three bodies, predicted the existence of a new, a hitherto unobserved planet at an even greater distance from the sun. The miracle came to pass; for Gottfried Galle, on the very same evening, discovered the predicted new star Neptune, almost exactly at the point of the heavens for which it was prophesied, only half the moon's diameter from it.

Our own time has been marked by an event of even greater significance. In the case of the planet Mercury, the motion of the line joining sun to planet, when in perihelion, while very slight, shows an accumulation according to calculation by the Newtonian mechanics of 532 seconds in a century; whereas the actually observed amount was found to be 574 seconds, leaving an excess of 42 seconds to be accounted for. Allowing for all possible perturbations due to the other planets, the Newtonian mechanics were powerless to explain this baffling discrepancy. In 1910 the great French mathematician, Poincaré, pointed out that here was a striking opportunity for testing the validity of the new mechanics. On November 18, 1915, Einstein presented a paper to the Prussian Academy of Sciences in which, according to the mechanics of his Generalized Relativity Theory, calculation provides exactly for the missing 42 seconds of arc in which Newton's law is in default. The remarkable feature of this spectacular triumph is that Einstein's equations were not subject to alteration or approximation: it was forty-two seconds of arc or nothing—*Weltmacht oder Niedergang.* Whereas Leverrier in his time had pointed out a new planet, Einstein with his epochal theory brought to light something far more important: a new truth.

Pope's famous lines have been cleverly capped by the witty Englishman, J. C. Squire:

> Nature, and Nature's laws
>   lay hid in night.
> God said, Let Newton be
>   and all was light.
> It did not last
>   the devil howling *Ho!*
> *Let Einstein be!*
>   restored the status quo.

When Hertz more than half a century ago, building upon the theories of Faraday and Maxwell, discovered that electro-magnetic waves were propagated with the speed of light, he gave the prophetic clue to the marvels of wireless telegraphy, etheric conduction and the radio. The civilized world to-day is one vast complex of the most sensitive transmitters and coherers; and the delicate cobwebs of antennae spun by the scientist upon tenuous towers of steel flung up against the sky bring to our ears, as we sit in comfortable drawing-rooms, the voice of the explorer lost in Arctic wilds, the mellifluous notes of the great opera singer, news of the marvellous discovery of the buried tomb of an ancient Egyptian king, the latest message to his people of the president of this mighty republic. Multitudinous messages from the dim remote, the beneficent blessings of science, flock in upon our thrilled and enraptured senses; and the glorious dream of a collective consciousness of mankind is at last brought within measurable reach of human realization.

The political, social and ethical consequences of this new discovery are truly incalculable. The barriers of insularity and provincialism are at last transgressed and the voice of the humblest citizen can reach the ears of mankind. "The opportunity for a hundred millions to think together, feel together, and to act as a single corporate irresistible force", comments Faunce, "is something new in the history of mankind, something that surpasses all the dreams of science or education or religion. Has then the millenium arrived? Shall the golden age be ushered in by the microphone? Alas, no mechanism can usher in any millenium, and no material device can establish the Kingdom. of God. The broadcasting station will send out our message of brotherhood, or hiss out our hatred with equal efficiency. The Greeks had none of our devices, but they built the Parthenon and carved the Hermes—things utterly beyond us now. They had no microphone but they heard the voice of Sophocles. They never heard the hum of the aero-plane, but they listened to the 'surge and thunder of the Odyssey.' "

No one who seriously reflects upon the lagging advance of general intelligence can doubt the assertion of H. G. Wells that the scientist of to-day has forged far ahead of the main body of contemporary mind. "When the intellectual history of this time comes to be written", he trenchantly says in his *Outline of History*, "nothing, I think, will stand out more strikingly than the empty gulf in quality between the superb and richly fruitful scientific investigations that are going on, and the general thought of other educated sections of the community. I do not mean that scientific men are, as a whole, a class of super-men, dealing with and thinking about everything in a way altogether better than the common run of humanity, but in their field they think and work with an intensity, an integrity, a breadth, boldness, patience, thoroughness and faithfulness—excepting only a few artists—which put their work out of all comparison with any other human activity. . . . In these particular directions the human mind has achieved a new and higher quality and gesture, a veracity, a self-detachment, and self-abnegating vigor of criticism that tend to spread out and must ultimately spread out to every other human affair." To meet, to know, to work with the greatest scientists of to-day—and it has been my good fortune to know scientists of the type of Einstein, Rutherford, Planck and Michelson—is to realize that the wonderful scientific developments of the nineteenth century are but the earnest of vastly more comprehensive and colossal scientific achievements in the twentieth century. Annihilation of distance; the attainment of incredible speeds in new modes of locomotion; the precise investigation of the size and motions of objects a million times too infinitesimal for visual observation; the long-range study of gient nebulae so immense that they constitute island universes; the observation of changes so minute that but twenty-five years ago scientists would have denied the very power to make such measurements; these are among the supreme marvels of the age. Napoleon's headlong flight from Russia which took 312 hours, in the last lap from Vilna to Paris, is to-day traversed by airplane in one-fortieth of that time. Jules Verne's romantic projections of Captain Nemo and The Nautilus, of "The Mysterious Island" and "Twenty Thousand Leagues Under the Sea", were dwarfed into insignificance by the spectacular achievements of the submarines in the World War; and his fanciful story "Around the World in Eighty Days" was reduced to absurdity only the other day by the thrilling adventure of the world-fliers, the marrow-freezing flights over the North Pole of Byrd and Amundsen. Millikan won the Nobel prize in Physics for accurately measuring the electron, which would have to be magnified a billion times to be visible to the naked eye under a microscope. Einstein boldly staked his entire theory of Relativity on a shift in the spectral lines so minute that its very existence was questioned. And Niels Bohr divides the atom of radium into a central nucleus around which revolve in complicated orbits eighty-eight particles of electricity called electrons, each so minute that it is as far from the nucleus relatively as the earth is from the sun. Dean Swift wrote a famous romance in which Gulliver saw the Lilliputians as dwarfs; and the Lilliputians saw Gulliver as a giant. Relativity teaches that the Lilliputians would have appeared as dwarfs to Gulliver, and that Gulliver would have appeared to the Lilliputians, not as a giant, but as a dwarf. An idea too absurd for fiction is to-day deliberately set forth in the sober pages of science.

To-day, it seems to me, we are confronted with three great problems—upon which I can barely touch—problems bequeathed to us by the scientific efflorescence and mechanistic quality of this new century.

First, there is the great discrepancy to be bridged over between the super-intellects of the scientists and the crass stagnation of the average mind. Surely this is the most destructive canker in the flower of contemporary civilization. It is like the deadly monoxide which, any day, may sweep us into eternity at the moment we enter our garage to run out our beautiful, high powered motor car. I recently heard President Coolidge utter these words in an address at Washington to a great body of scientists: "You represent the interests, the forces, and the endless activities which literally from day to day are conquering new domains and adding them to the imperial realm of human knowledge. The future of civilization is well nigh in your hands. You are the wonder workers of all the ages. The marvels of discovery and progress have become commonplaces, simply because their number has paralyzed the capacity of the mind for wonderment. Those of us who represent social organizations and political institutions look upon you with a feeling of awe and something of fear, as we ask ourselves to what revolution you will next require us to adapt our scheme of human relations." Only a few days before his death, the great plant wizard, Luther Burbank, said: "The most promising aspect of American life is science and its marvelous advance in freeing the mind and body from superstition, slavery and fear." Whilst the search for truth has in our time become the foremost interest of the human race, our educational institutions have lamentably failed to bring up the level of average intelligence to the point of grasping the significance of the results in this search. Very recently, President Butler of Columbia pessimistically declared that "the extensive and intensive study of natural science, now carried on over more than a full generation, has made no impression whatever upon the public mind."

I venture to suggest, as a remedy for this lamentable state of affairs, the teaching of science as a great adventure, a great romance. "It is no longer possible to deny", says Havelock Ellis, "that science is of the nature of art." Professor Einstein once remarked to me that, after a certain high level of scientific evolution is reached, science and art both become merged into esthetic, plasticity and form. "Man seeks to form a simplified synoptical view of the world", he said in a memorable address, "in a manner conformable to his own nature, in order to overcome the world of experience by replacing it, to a certain degree, by this picture. This is what the painter does, as also the poet, the speculative philosopher, and the research scientist, each in his own way. He transfers the centre of his emotional experience into this picture, in order to find a sure heaven of peace, one such as it not offered in the narrow limits of turbulent personal experience." Daniel Gregory Mason, professor of Music at Columbia University, recently said in my hearing that Bertrand Russell's classic description of mathematics, which I shall quote, is equally valid and true if everywhere we replace the word "mathematics" by the word "music." Says Russell: "The characteristic excellence of mathematics is only to be found where the reasoning is strictly logical; the rules of logic are to mathematics what those of structure are to architecture. In the most beautiful work, a chain of argument is presented in which every link is important on its own account, in which there is an air of ease and lucidity throughout, and the premises achieve more than would have been thought possible, by means which appear natural and inevitable. Literature embodies what is general in particular circumstances whose universal significance shines through their individual dress; but mathematics endeavors to present whatever is most general in its purity, without any irrelevant trappings."

In the future, I submit, if we are to reach the great public, Science must be taught as Art—Einstein's Relativity as great an esthetic triumph as Shakespeare's "Hamlet", Dante's "Inferno", or Goethe's "Faust."

In the second place, the human being of to-day, through the influence of mechanistic technic in an age of science, is becoming Robotized to an alarming extent. You and I, my friends, are Robots to a greater or less extent—doing each day an enormous amount of mechanical and routine work, which requires little thought, no originality—merely efficiency and machine-like accuracy. In the days of the Middle Ages, in the golden era of the Crafts and Guilds, a workman was an artist, who made every part of a mechanism—whether it were a clock or a tapestry, a *Cloisonné* vase or a Damascus blade. To-day we are victims of quantity production; and our works, both of art so-called and of utility, are "assembled products." A workman in a Ford factory does not make a Ford car; he makes over and over again, to the destruction of all scientific initiative and craft instinct, the selfsame part. The real menace of mankind to-day is the menace of the machine. For it tends to make man himself a mere automaton, a machine. The curse of civilization and in especial of American civilization is the tendency to the standardization of the human product.

Our educational institutions are becoming machines for turning out human products according to a given pattern and prescribed design. The convoy system of education, the cafeteria philosophy of hand-picked information, the department store and bargain counter program are yielding place to the cash-register doctrine, by which all students are taught according to mechanical scales of mental cross-indices, information credit slips and artificial time units. Thousands of young men and women are poured each year out of these palatial hoppers, called colleges and universities, with no more individuality than so many bricks, so many sausages, so many Teddy Bears. In this hazardous experiment called democracy, what educational opportunity is allowed for the free flowering of genius? Education in our democracy to-day is spelling failure—since it does not supply vent for the spontaneous, space for the random, and freedom for the genius.

Last of all, science to-day raises ghosts of disquiet which haunt our visions of the future. That Edward Bellamy of the new science, J. B. S. Haldane, gaily executes a gaudy and kaleidoscopic futurist painting of the world a thousand years in the future. But he fills us with concrete alarm when he launches forth into a serious defence of chemical warfare. What price the World War? Are the miraculous discoveries of science to be ruthlessly turned into deadly instrumentalities for the destruction of civilization itself? That this danger, though chemical, is by no means chimerical, is well illustrated in these significant words of Bertrand Russell in his recent book on the future of science: "Men's collective passions are mainly evil; for the strongest of them are hatred and rivalry directed toward other groups. Therefore at present all that gives men power to indulge their collective passions is bad. That is why science threatens to cause the destruction of our civilization. The only solid hope seems to lie in the possibility of world-wide domination by one group, say the United States, leading to the gradual formation of an orderly economic and political world-government." Surely to men and women of good-will a purer, larger vision for the future of civilization is Woodrow Wilson's dream of a League of Nations, animated by the spirit of human brotherhood and the Christian doctrine of brotherly love. In the apocalyptic vision of Ezekial, where we may distinguish in "the wheels" Science and in the "living creature" Humanity, the clue to the future peace and happiness of mankind lies in breathing into the lifeless body of scientific mechanism the spirit, the soul of Christianity. "For the spirit of the living creature *was* in the wheels. When those went, *these* went; and when those stood, these stood; and when those were lifted up from the earth, the wheels were lifted up over against them; for the spirit of the living creature *was* in the wheels."

And now, my young friends, I wish to leave with you this thought and adjuration. The future of the race—and that means, primarily, the future of American civilization—rests with the women, with you. Are you going after your Ph.D.'s like the young woman I heard of not long ago? After taking post-graduate work for a year and a half, she married one of her professors. Whereupon a friend exclaimed: "Why, I thought you were going to get your Ph.D.!" And the young lady blithely replied: "I did get my Ph.D.; but I got him sooner than I expected." But, aside from the manifest destiny of man—to be caught in the tangles of Naeaera's hair—my appeal is made to the free, joyous, aspiring, courageous woman of to-day—with larger dreams and ampler hopes than the mere pursuit of happiness. I would urge you to break away from the hampering shackles of our mechanical civilization, and to assert your independence—with which I am assured you of the new generation are so plentifully endowed—in the higher world of creative thought and energy. Lift your minds above the merely local and ephemeral issues of Main Street, of Zenith and Cactus City, and deal with the higher phases of life—with science, art, and philosophy, and with the amelioration of the lot of humanity. May life be for all of you, always, a true migration into uncharted seas of adventure! May you "put into port greatly, or sail with God the seas!"

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